Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

200 kinds of trains altogether, represented in their connection by graphs, so that a glance furnishes intuitive evidence of their essential difference. For the groupless systems Miss Cummings gives a table of the indices which represent the sequences of each system, and comparison is not difficult. She exhibits also a table of the four varieties of interlacing of pairs, as distinguished by Mr. Cole, showing how many of each kind are found in each system. These latter data alone are found, in eight cases, to fail to discriminate two systems actually different. Perfect discrimination would almost certainly be possible by the use of a double entry table, 15 by 15, showing the exact distribution of tetrads, hexads, oktads, and dodekads.

NEW DATA ON THE PHOSPHORESCENCE OF CERTAIN SULPHIDES

(DISCUSSING MEASUREMENTS BY DRS. H. E. HOWE, H. L. HOWES AND PERCY HODGE)

By Edward L. Nichols

DEPARTMENT OF PHYSICS, CORNELL UNIVERSITY[1]

Read before the Academy, November 14, 1916

Ph. Lenard to whom we owe extended studies of the class of highly phosphorescent substances known as the Lenard and Klatt[2] sulphides, describes[3] the spectrum of the emitted light as consisting of a single broad band in the visible spectrum. This band which appears single in most cases, as viewed with the spectroscope, does not however conform to the recognized criteria. The marked difference between the color of fluorescence and that of phosphorescence and the changes of color during decay, suggest over-lapping bands. As shown by E. Becquerel[4] the color of the emitted light varies with the wave length of the exciting rays. His observations apply, it is true to sulphides of barium, calcium and strontium not identical with the preparations of Lenard and Klatt, but belonging to the same class. In a recent paper[5] I gave more direct evidence of the existence of more than one band in the spectra of these substances.

In their original paper[2] Lenard and Klatt depicted these spectra as complex instead of single; but in both the earlier and the later papers attention is given rather to the mode of excitation than to the character of the phosphorescent light itself and the regions of excitation in the violet and ultra violet are carefully mapped.

Significance of the Bands of Excitation.—It seemed probable that these regions of maximum excitation, the positions and appearance of which had long since been depicted by Becquerel, were due to the presence of absorption bands. Dr. H. E. Howe, who was employed last summer in the study of ultra violet absorption spectra, was kind enough to test this hypothesis.

In his experiments the phosphorescent substance was exposed to the continuous ultra violet spectrum of the powerful submerged aluminum spark described by Henri[6] and subsequently employed by Howe[7] in his study of absorption spectra. The bands of excitation (Erregungsbände of Lenard) were thus located and with these absorption bands of the phosphoresent substance, obtained by reflection, were shown to coincide in position and extent. In the case of a barium sulphide with lead as an active metal, the crests of the bands of excitation were at 0.380μ and 0.335μ. Lenard gives for a sulphide of similar composition, 0.377μ and 0.332μ.

The crests of the absorption bands are at 375μ and 332μ. Similar coincidences were established in the case of Sr, Zn and Sr, Pb sulphides and the relation is therefore probably a general one corresponding to that already established in the case of the selective activity of infra red rays upon the phosphorescence of zinc sulphide,[8] where the maximum effect was found in regions of maximum absorption.

Spectrophotometric Measurements.—A detailed spectrophotometric study reveals widely varying degrees of complexity in the spectra of these sulphides.

Dr. H. L. Howes kindly made for the writer very careful measurements of three characteristic compounds. Settings were made at intervals of 50 Angstrom units throughout the spectrum.

The curves thus obtained show the existence of many overlapping bands so nearly merged that to the eye the appearance is that of a single simple band. There is moreover a distinct suggestion of a systematic relation.

Taking the relative frequencies, i.e., reciprocals of the approximate wave lengths of the crests ($1/\mu \times 10^3$) it is found that the over-lapping bands are members of one or more series of constant frequency interval; which interval varies for the different sulphides.

Whether the spectra under consideration are to be regarded as consisting of a single band or of more than one band is not a question of complexity of structure.

Any system however complex which behaves as a unit under varying conditions of temperature, mode of excitation, etc., all the components being affected in like manner, may be considered as a single band in the sense in which that term has been used by Lenard. We have a striking example indeed of such bands or systems of great complexity of structure in the case of the uranyl salts.

The evidence that, in general, the spectra of the phosphorescent sulphides contain more than one band or complex has already been mentioned, e.g., the marked changes of the color of phosphorescence with temperature and during the process of decay.

The Decay of Phosphorescence in Different Parts of the Spectrum.—To obtain the curve of decay for a restricted region of the spectrum Drs. Howes and Hodge used a spectrophotometer in combination with the synchrono-phosphoroscope. In this way a set of curves corresponding to several nearly equidistant regions within the phosphorescent spectrum were obtained for each of the three sulphides under consideration.

A notable feature of all these curves is the existence of two so-called linear processes the first of steeper slope and therefore indicative of a more rapid decay of phosphorescence than the second. This form of curve, as is well known, is characteristic of phosphorescent substances in general, the only well established exceptions being those occurring in the case of the uranyl salts.[9] As regards the relation of the two processes recorded in these diagrams to what appear as the first and second processes in the usual study of the long time phosphorescence of such sulphides, it is clear that the second process in our curves is not identical with the first process as observed by the usual long time methods. Assuming the second process to continue, the intensity after one second would be about 1/1000 of that at 0.01 second or roughly 1/20,000 of its initial brightness whereas as is well known these substances retain an easily visible phosphorescence after many seconds.

Owing to the over-lapping of the components in the spectra under consideration it is difficult to determine whether the group of equidistant bands are to be regarded as a unit, as is in the case of the uranyl salts or indeed whether they constitute the whole of the phosphorescence spectrum. To that end some method permitting of more complete resolution must be devised.

The pronounced changes in the color of the phosphorescent light would make it seem probable that we have to do in these observations chiefly with components of the phosphorescence that are of rapid decay and that, after a few hundredths of a second, these disappear leaving behind other components which constitute the phosphorescence of long duration. These, which are probably of relatively insignificant initial brightness, doubtless overlap the phosphorescence of short duration but occupy, as a whole a somewhat different portion of the spectrum.

In that case since one has to do with a different group of bands in observing the initial and the later phases of phosphorescence there would be an actual discontinuity between the processes referred to above and those in the curves for the phosphorescence of slow decay.

Summary.—(1) The regions of selective excitation (the bands of excitation) for the Lenard and Klatt sulphides are shown to coincide in position and extent with absorption bands in the transmission spectrum of the substances.

(2) The spectrum of the phosphorescent light during the first few thousandths of a second after the close of excitation, contains one or more groups of over-lapping bands the crests of each group forming a spectral series having a constant frequency interval.

(3) The decay of phosphorescence during the first three hundredths of a second after the close of excitation may be described as consisting of two processes each showing a linear relation between $I^{-\frac{1}{2}}$ and time. The first and more rapid process lasts for less than 0.01 second for the three sulphides studied under the intensity of excitation employed. The second process probably persists for 0.06 seconds or more.

(4) The phosphorescence of long duration of the sulphides under consideration is probably due to another group of bands of comparatively feeble initial brightness which come under observation only after the phosphorescence of short duration has vanished.

---

[1] The investigation was carried out in part with apparatus purchased by aid of a grant from the Carnegie Institution of Washington.

[2] Lenard and Klatt, *Ann. Physik, Leipzig*, (Ser. 4), **15**, 1904, (225).

[3] Lenard, *Ibid.*, **31**, 1910, (641).

[4] Becquerel, E., *La Lumière*, Vol. 1, 1861.

[5] Nichols, *Philadelphia, Proc. Amer. Phil. Soc.*, **55**, 1916, (494).

[6] Henri, V., *Physik. Zs., Leipzig*, **14**, 1913, (516).

[7] Howe, *Physical Rev., Ithaca*, (Ser. 2), **8**, 1916, (637).

[8] Nichols and Merritt, *Washington, Carnegie Inst., Pub.*, No. 152, (84).

[9] Nichols, these PROCEEDINGS, **2**, 1916, (328).

THE REACTIONS OF THE MELANOPHORES OF THE HORNED TOAD

By Alfred C. Redfield

ZOOLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD COLLEGE[*]

Communicated by G. H. Parker, February 3, 1917

The reactions of the melanophores of the horned toad Phrynosoma cornutum are of three distinct types: (1) Those which manifest themselves in a daily rhythm of reactions, correlated with definitely changing

---

[*] Contributions from the Zoological Laboratory of the Museum of Comparative Zoology at Harvard College, No. 292.